Matrix Organization: An Approach to Effective and Continuing Interdisciplinary Team Functioning

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At this point in history, there is general recognition that the nature of the problems we face requires effective multiple discipline attack. We have, perhaps unconsciously, been thrust into a brave new world in which mankind has the capability to control his environment and shape his own destiny. This brave new world requires new perspective. As described by Kenneth Boulding, the economist:

"We must visualize the earth as a small, rather crowded spaceship, destination unknown, in which man has to find the slender thread of a way of life in the midst of a continually repeatable cycle of material transformation. In the spaceship, there can be no inputs or outputs, the water must circulate through the kidneys and algae, likewise the food and air. In the spaceship, there can be no sewers and no imports."

Development and maintenance of an environment conductive to public health, safety, and general welfare is highly involved. It includes legal, ethical, medical, technological, economic, social, cultural, aesthetic, and political considerations. For those in the environmental design professions, the technical phases are of major significance. Providing shelter, food, water, power, transportation, recreation, and all other physical features of environment is dependent on application of theory and practice in the natural sciences.

Great responsibilities rest on those firms, institutions and individuals who undertake efforts toward environmental improvement. No one individual can possibly attain the knowledge and skills which need to be involved and integrated for best results. Hence, multiple discipline team work is essential to blend the capabilities of the various professions.

Historically, the performance record of the environmental design professions has not been ideal. A case can be made that many of our environmental problems exist today because our solutions to past problems have been sub-optimal. We have tended to draw boundary conditions too tightly in developing design solutions. The result has, in the long run, been less than desirable. For example, it is quite simple and, in the short run, economical to solve the liquid wastes problem of a city or industry if boundary conditions are drawn tightly enough to include only that area within the

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city limits or plant fence. Waste may be transported by sewer to the
nearest waterway. This solves, for the time being, the liquid waste
problem for the city or industry, but creates problems elsewhere.
Similarly, the problems of electric transmission and distribution
are easily solved if the boundary conditions drawn eliminate
aesthetic considerations.

The world view expressed by Kenneth Boulding does not allow
such a limited definition of boundary conditions. The major
emphasis needed in the environmental design professions today is
a major expansion of the factors considered in making design deci­sions. A systems approach integrating many professions into mul­
tiple discipline teams is required.

On this basis, let us address ourselves to the problem of creat­
ing the organizational environment within which effective and con­
tinuing interdisciplinary team functioning can take place.

Effective multiple discipline teamwork requires that two condi­tions be met:

1. Each discipline must be competent. This requires an organiza­
tional structure or pattern of operation which will encourage
training and development within each discipline and which will
provide easy opportunity for members of the discipline to consult,
check, review and approve work within their discipline.

2. The various disciplines must be integrated. Each multiple
discipline undertaking must be planned, organized, directed, coor­
dinated, and controlled effectively. This requires a task or project
oriented organizational structure or pattern of operation which en­
courages communication and encounter between disciplines to most
fully satisfy task or project requirements.

These two conditions place conflicting demands on the manage­
ment and organizational structure of an ongoing firm or institution.

At the extremes of practice, both discipline oriented and project
oriented approaches have been used.

We are all familiar with task force groups which have been
pulled together from time to time to deal with specific problems.
A recent example is the group assembled to evaluate the Apollo
13 difficulties. In such a situation, the task force is specifically
designed for the problem at hand. The members of the task force
or project team are selected because of competence in their respec­
tive disciplines, thus meeting the first condition described above.
The organizational structure of the task force is designed to provide
integration of disciplines. If it does so, the second condition for
effective multiple discipline endeavor is met. Such ad hoc task
forces or project teams can be very effective in dealing with specific
one-time problems. However, their shortcoming is continuity as
well as training and development of younger members of the vari­
ous disciplines. Once the specific task or project is completed, the
task force is normally dismantled. Each member may have devel­
oped somewhat in the process, but the development becomes widely
dispersed. The task force is unavailable for future involvement in similar situations.

An alternate organizational approach is organization by discipline. This approach is commonly used by ongoing institutions and organizations. Major departments or divisions are organized by discipline. This facilitates development of competence within the discipline. It provides for training and development of younger members of the discipline. This organizational approach fulfills condition one. Its common shortcoming is its failure to fulfill the second condition required for multiple discipline endeavor. Any departmental organization has an inherent tendency for disciplines to become progressively more narrow, specialized and isolated. In an institution or firm composed of one-discipline departments, this tendency normally exerts itself, reducing or eliminating integration of diverse disciplines.

The matrix organization concept is a compromise between organization by discipline and organization by project or task. The title, matrix organization, is drawn from the mathematical analogy. In a mathematical matrix, each element is related both vertically and horizontally to the other elements in its column or row. Such relationships exist simultaneously.

Similarly, in matrix organization, each element (person) has simultaneous relationships with other persons in his discipline and with persons in different disciplines comprising a project team.

As developed by Stanley Consultants, matrix organization includes a permanent line organization broken down by discipline. Concurrently, members in the various departments are assigned to project teams as required to meet needs of the specific project. Thus, each member is simultaneously a member of a permanent department and one or more project teams. From his one-discipline department he draws resources, support, reviews and approvals as may be required to assure that his contribution to the project team is sound from the standpoint of the discipline. As a member of a project team, he has direct communication and encounter with other disciplines to achieve optimal interdiscipline balance. The permanent line department provides for training, development and permanence of members. The project team, headed by its project manager, provides planning, organizing, direction, coordination and control of the specific project activity. Thus, the matrix organization concept provides for both competence within each discipline and integration of various disciplines.

On the surface, this organizational concept violates one of the generally accepted precepts of organization; i.e., no subordinate should have more than one supervisor. Yet this precept is commonly violated by service and professional organizations. For exam-
The everyday variety store sales clerk has, in a sense, two masters. The clerk must serve the customer and fulfill all obligations to him in order to produce the sale. At the same time, the clerk has obligations to the store or department manager. Both of these obligations must be satisfactorily met if the clerk is to perform effectively.

Similarly, the member of a matrix organization has dual responsibilities. He is responsible to the head of his one-discipline department for effective handling of the matters that fall within his discipline, including obtaining the necessary assistance, reviews and approvals. At the same time he is responsible to his project team manager for effective interrelationship with other disciplines and effective contribution toward meeting overall needs of the client or the project team objective.

The advantages of matrix organization are numerous. They include the following:

1. The conditions required for effective multiple discipline endeavor are met. Matrix organization provides for competence within each discipline, as well as integration of the various disciplines.

2. Continuity is provided. As a given project or task is completed, the members involved in that project or task become available for assignment to other projects. Hence, their services are not lost to the institution or firm, but rather the knowledge gained on the specific project is retained and easily transmitted to others.

3. Matrix organization facilitates variations in level of project effort. Typically, the beginning, ending and some intermediate phases of work on a specific project or task do not require full time effort from all project team members. With matrix organization, the time of project team members which is not required on one particular project can be diverted to other projects. This encourages efficient use of time as well as continued availability of project team members for miscellaneous odds and ends which may need attention after the major effort is completed.

Stanley Consultants is a multiple discipline, international consulting firm practicing in the disciplines of engineering, architecture, planning and management. While our matrix organization approach has similarities with organizational approaches used in other consulting and industrial organizations, it is a concept which has largely been developed by Stanley Consultants to meet the need for continuing and varied multiple discipline team efforts on a wide variety of projects.

Nevertheless, the matrix organization approach could significantly strengthen interdisciplinary capability of other institutions.
and organizations. Inasmuch as a large percentage of the attendance at this session represents engineering education, it is appropriate to outline some of the advantages matrix organization might have if applied to engineering colleges.

As a consulting firm, Stanley Consultant is very much interested in the qualifications and capabilities of the graduates of engineering colleges. As we seek to fill various engineering positions within the firm, we usually have the greatest difficulty in finding able candidates for those positions which require broad integration of various disciplines. In seeking candidates for such positions, we are more concerned about attitudes and personal characteristics than specific competence in any one discipline. Such individuals must have a broad appreciation for the contribution that can be made by various disciplines. They must have the capability to draw on the knowledge of able professionals in the respective disciplines, to work out compromises between disciplines, and to ask the right questions at the right times.

The difficulty we face in filling such positions is not surprising when one considers the relative lack of interdisciplinary education in most colleges of engineering. Typically, engineering colleges are organized along strict discipline lines and interdepartmental communication and coordination is limited. This tendency toward rigid departmentalization would be alleviated if matrix organization approach were applied in a manner consistent with recommendations of the Final Report of the Goals Committee of the American Society for Engineering Education on "Goals of Engineering Education." This report, issued in January, 1968, includes a number of recommendations which would move in the direction of establishing interdepartmental multiple discipline efforts.

Significant among these recommendations are:

1. Greater breadth—increased liberal course content—in engineering education. Such liberal courses will enhance the capability of the engineer to be an interdisciplinary practitioner.
2. Diversity, as opposed to uniformity, in educational programs as well as flexibility in accreditation requirements.
3. Experimental masters programs emphasizing design.
4. Broadening the concept of the doctorate degree beyond research.
5. Continuing education for faculty members, including participation in non-educational industries and firms.

Adoption of these recommendations by engineering colleges is highly desirable. Too often present educational programs tend to reduce rather than enhance interdisciplinary capabilities. Emphasis for faculty and, hence, educational programs suffers from the tradi-
tional position that a thesis topic must be an “original contribution to knowledge.” Little or no recognition is allowed for team effort. Hence, educational institutions tend to build succeeding generations of faculty members caught up in the “publish or perish” single discipline syndrome.

This situation was outlined in a letter to the Editor of Science dated January 16, 1970, from Dr. Bruce Johnson, Director of the Hydromechanics Laboratory at the United States Naval Academy. His letter stated in part:

“Interdisciplinary team efforts, desperately needed in the crisis areas, are discouraged by the nature of the graduate schools. Most professors in the scientific disciplines like to direct dissertations which they can comprehend and not be embarrassed by their own lack of knowledge. Graduate deans and the faculty are hesitant to accept an innovative design thesis involving the solution of a real engineering problem. How does the committee evaluate the design unless it is built? Negative results are to be avoided and interdisciplinary efforts involve the additional risk of human non-communication resulting from differences in jargon and mathematical sophistication. What if the group doesn’t ‘jell’? Then there is the problem of ‘who’s in charge’ which brings out petty jealousies and charges of ‘encroachment’ and ‘empire building’ between deans and department heads afflicted with the ‘Peter Principle.’

“There are signs of hope in the few professors who are ‘damning the torpedoes’ by organizing interdisciplinary efforts outside their accustomed disciplines. However, the rewards in terms of departmental support, promotion, and pay increases are generally not commensurate with those of the ‘establishment professors’ who turn out many papers each year in relatively narrow fields and enjoy immense national reputations within the one or two professional societies to which they belong. Once this reputation is established, some professors become interested in interdisciplinary studies and eventually become honorary members of several societies. This serves to alleviate any guilt feelings they might have for neglecting ‘crisis’ problems during their most creative and productive years devoted to research.”

Fortunately, there are hopeful signs at the Iowa Colleges of Engineering. A few pilot efforts are underway on interdepartmental programs, primarily at the graduate level. However, more effort is needed. Interdisciplinary and design type programs need to be introduced at the undergraduate level and efforts toward breaking down the walls which divide departments are needed in all areas.
The matrix organization approach will allow the maintenance of a departmental organization concurrent with interdisciplinary activity. This may help to bring to the student at both graduate and undergraduate level the realization that both competence in discipline and integration of disciplines is required to meet the major problems facing us today.

Changing situations require new approaches. "Space ship earth" will continue to be inhabitable only if man can utilize its resources wisely and for his long term well being. The probability of this is enhanced by effective and continuing use of interdisciplinary teams with competence in disciplines as well as integration of them. The matrix organization concept, properly applied, is a means for achieving this end.